USING GPS RECEIVER 1PPS OUTPUT TO VERIFY TIME STAMP ACCURACY AND MEASURE PROPAGATION DELAY

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Agenda

- Introduction
- Purpose
- Test Cases
- Circuit Design
- Preliminary Test Results
- Chapter 10 Recorder Test Results
- Recommendations
- Questions?

Introduction

Measuring time stamp accuracy and signal propagation delay within telemetry/communication equipment can easily be done by overlaying a very precise 1 Pulse/Second (1PPS) time signal output from a GPS receiver into a standard PCM telemetry data stream. Overlaying this 1PPS signal into a telemetry PCM data stream provided an easy highly accurate method to measure time stamp accuracy and propagation delay on telemetry data processing and communication equipment.

Purpose

- Create a unique test signal to validate vendor's claim of better than 1µs time stamp accuracy on their Chapter 10 recorder

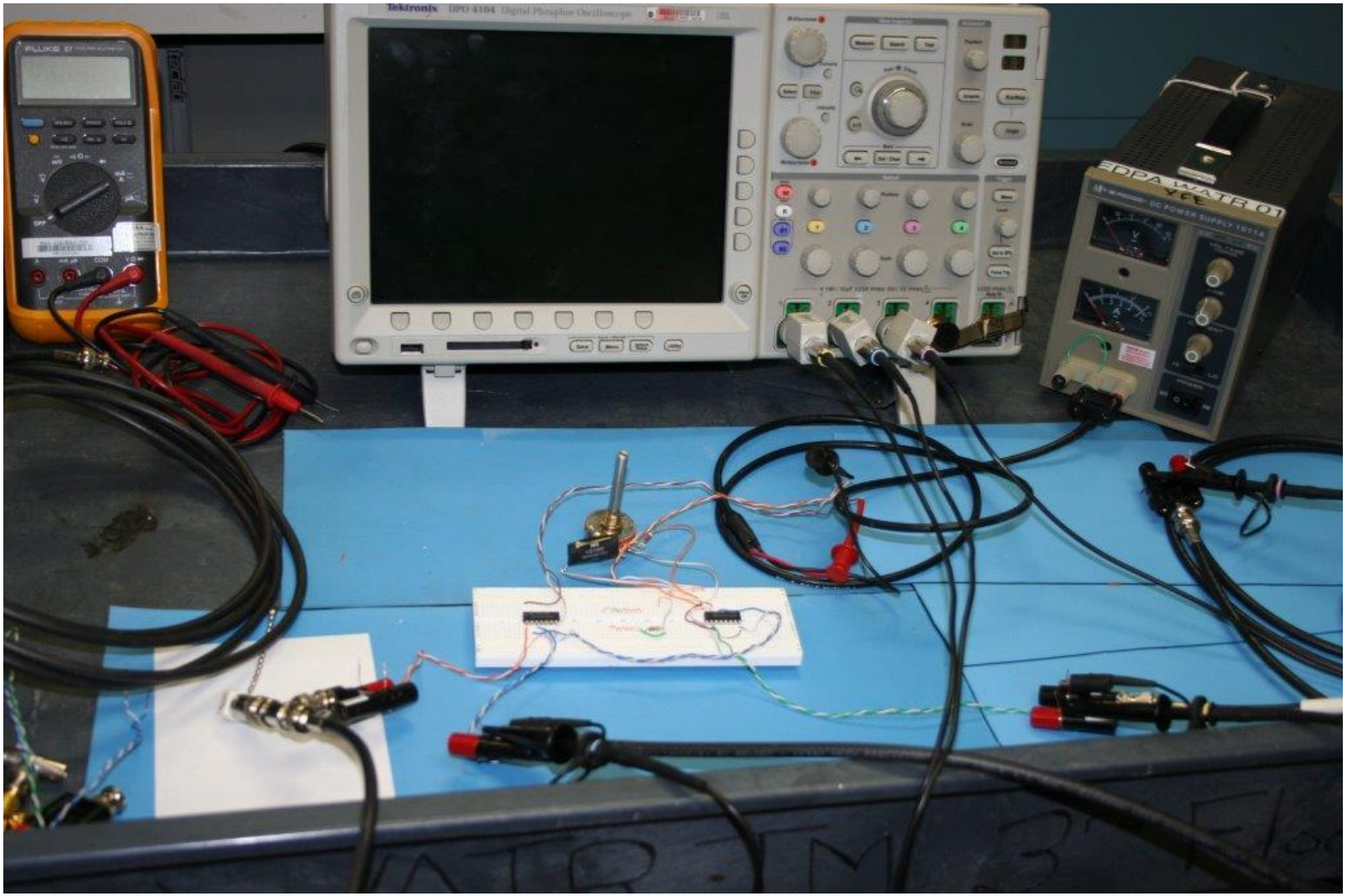
- Build a Pulse Overlay Circuit to overlay a GPS receiver very accurate 1PPS output signal into a standard telemetry PCM data stream to measure time stamp accuracy and propagation delay on telemetry data processing and communication systems

Test Cases

1. Measure time stamp offset using the unique overlaid 1PPS signal data pattern
   - Chapter 10 recording, with/without 1PPS connected to recorder.
     - » Vendor reports accuracy to be better than 10 µs without 1PPS and better than 1 µs with 1PPS
   - Processed telemetry data real-time and archive

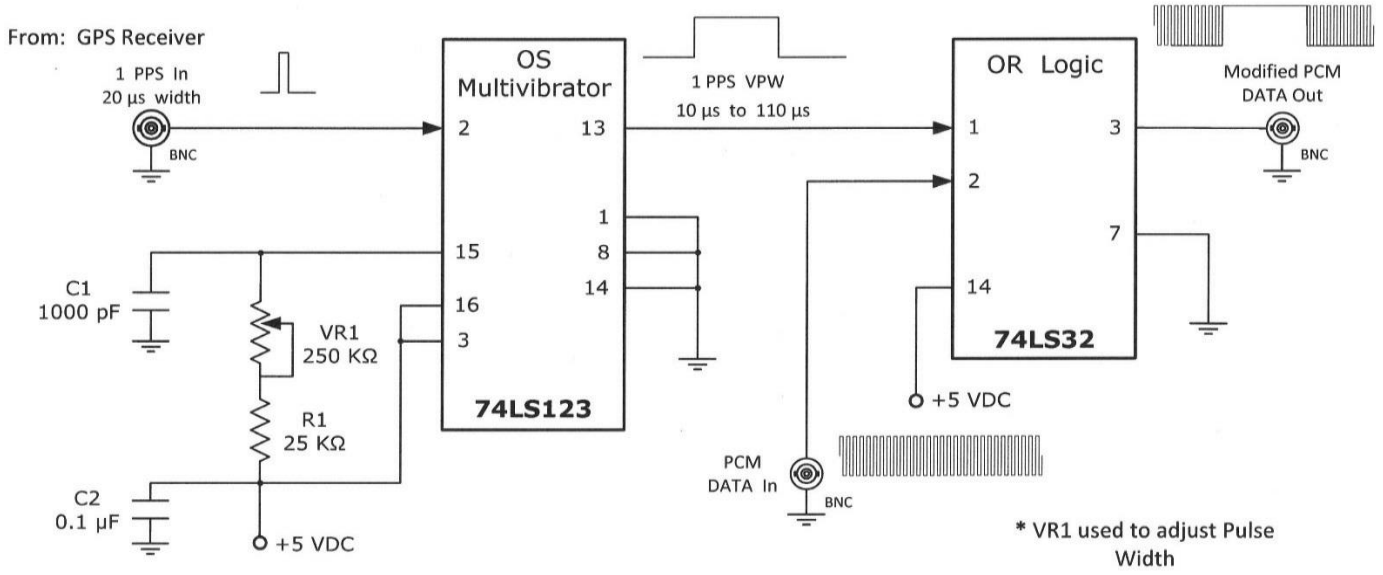
2. Measure signal latency
   - OC-3 multiplexer/demultiplexer
   - Bit synchronizers
   - Analog video modems

Circuit Design



Circuit Design

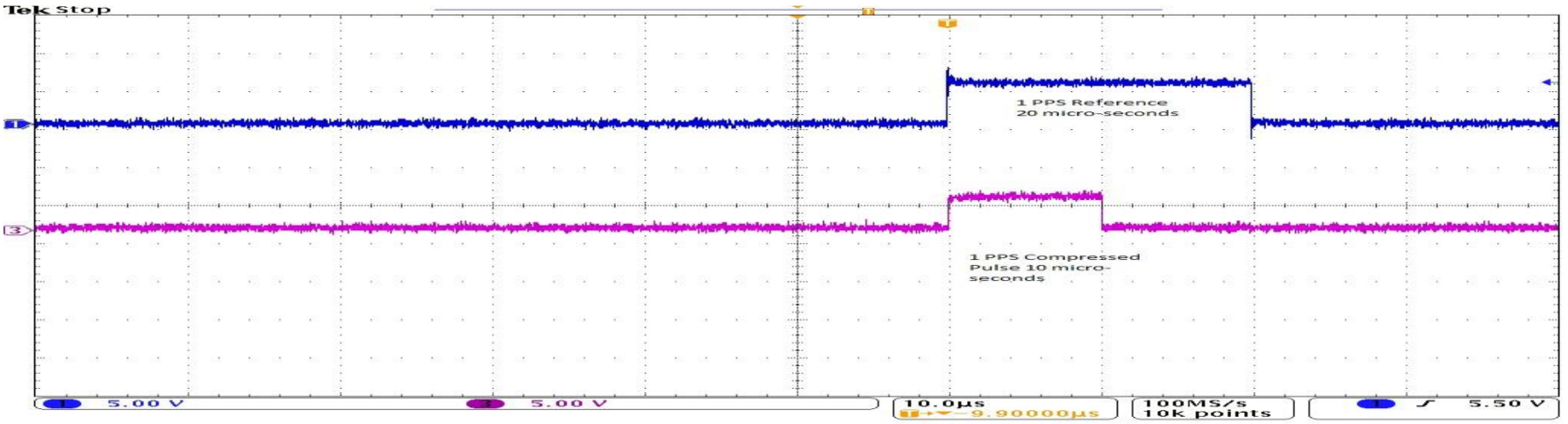
- Pulse Overlay Circuit

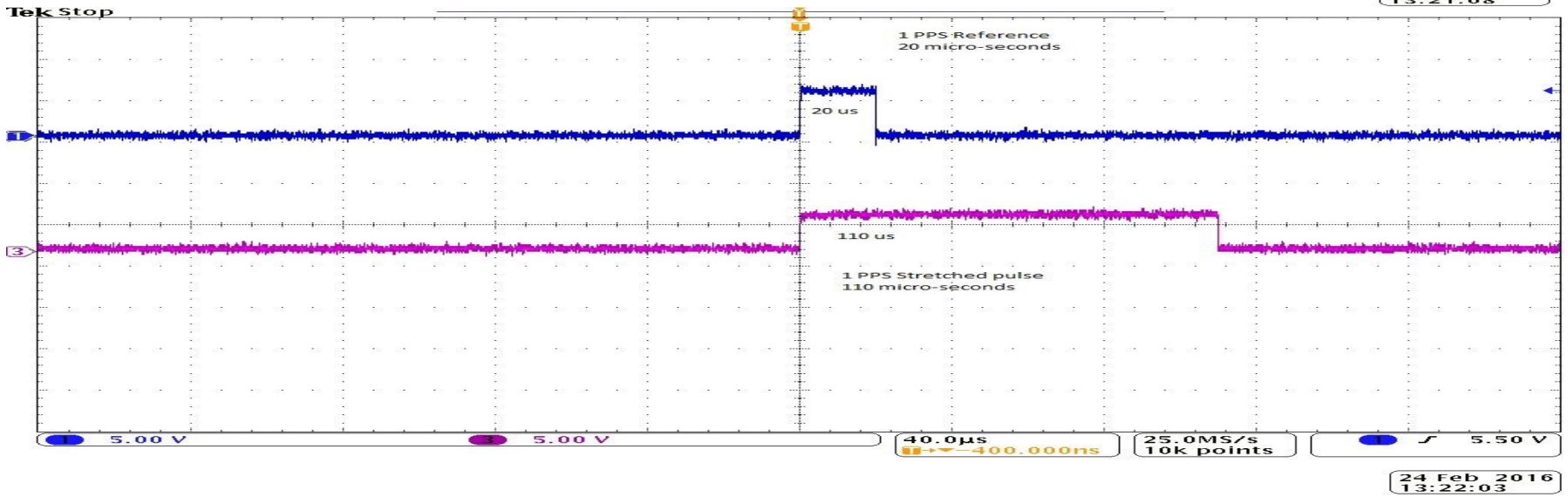


This presentation used a simple logic “OR” gate to overlay a 1PPS variable pulse width (VPW) signal into a telemetry PCM data stream. A one shot multivibrator circuit provides an adjustable pulse width for the 1PPS from ~10 µs -110 µs, while only adding a maximum 32 ns delay. The 1PPS VPW is overlaid on the PCM data stream by the OR gate.

Note: The GPS receiver 1PPS has a 20 µs pulse width with leading edge ±30 ns RMS & 100 ns peak offsets from true on the second.

Circuit Design



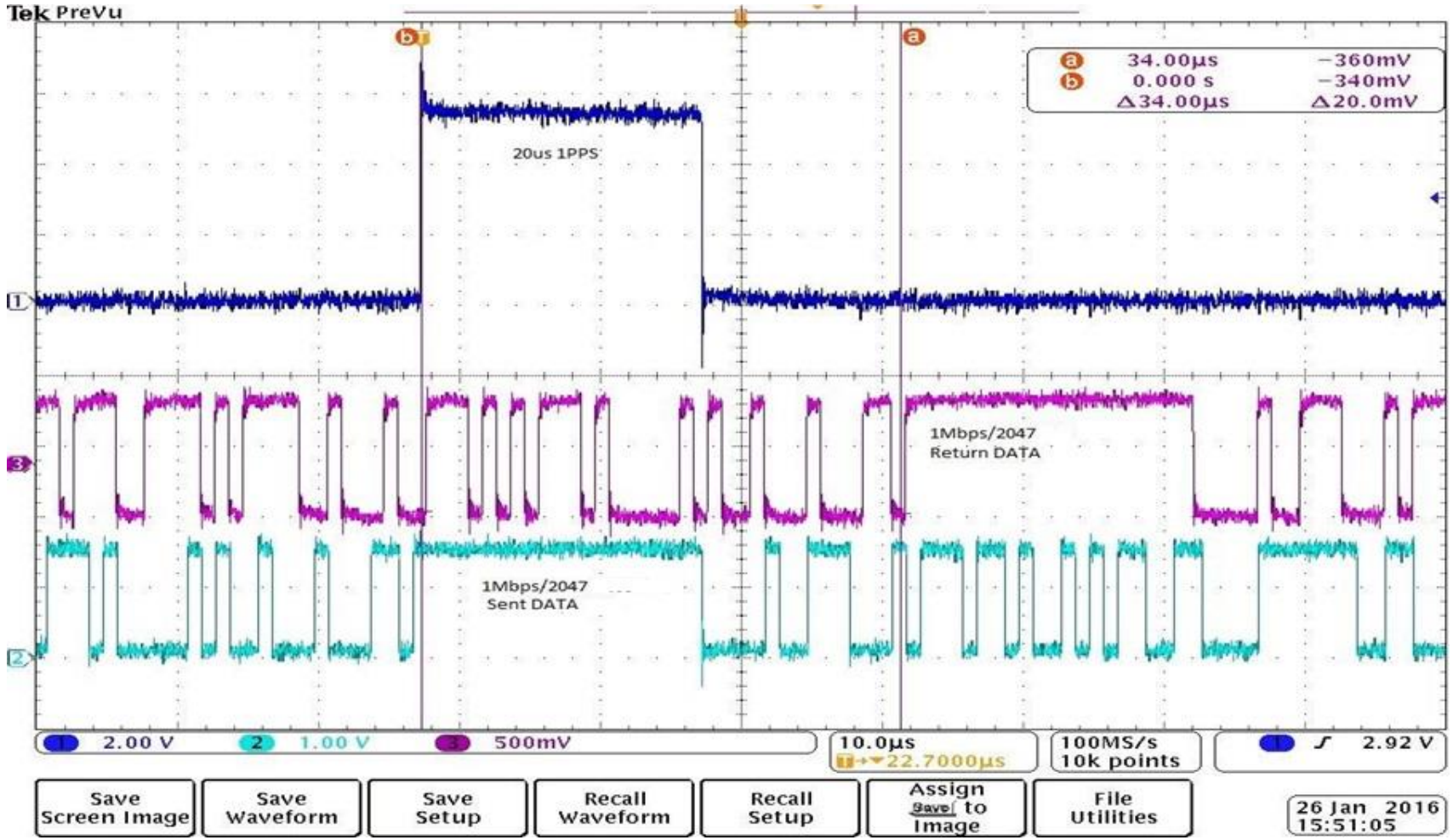


Preliminary Test Results

Measured latency of a 1 Mbps telemetry stream going through ~3296.412 meters of one way 62.5/125-µm multimode fiber transceiver lines (see next slide)

- ~34 µs latency round trip or ~17 µs one way
  - 11/03/14: One-way OTDR fiber link test read latency of 16.394 µs. Basic cable formula indicates latency to be 16.394643 µs.
    - » Pd= 3296.412 meters x 1.491/ (2.9979 x 10^8) meters-second= 16.394643 µs (Pd= L*Ng/c).
    - » Pd: propagation delay in seconds
    - » L: length of fiber in meters
    - » Ng: fiber index of refraction
    - » c: speed of light in vacuum

Preliminary Test Results



Preliminary Test Results

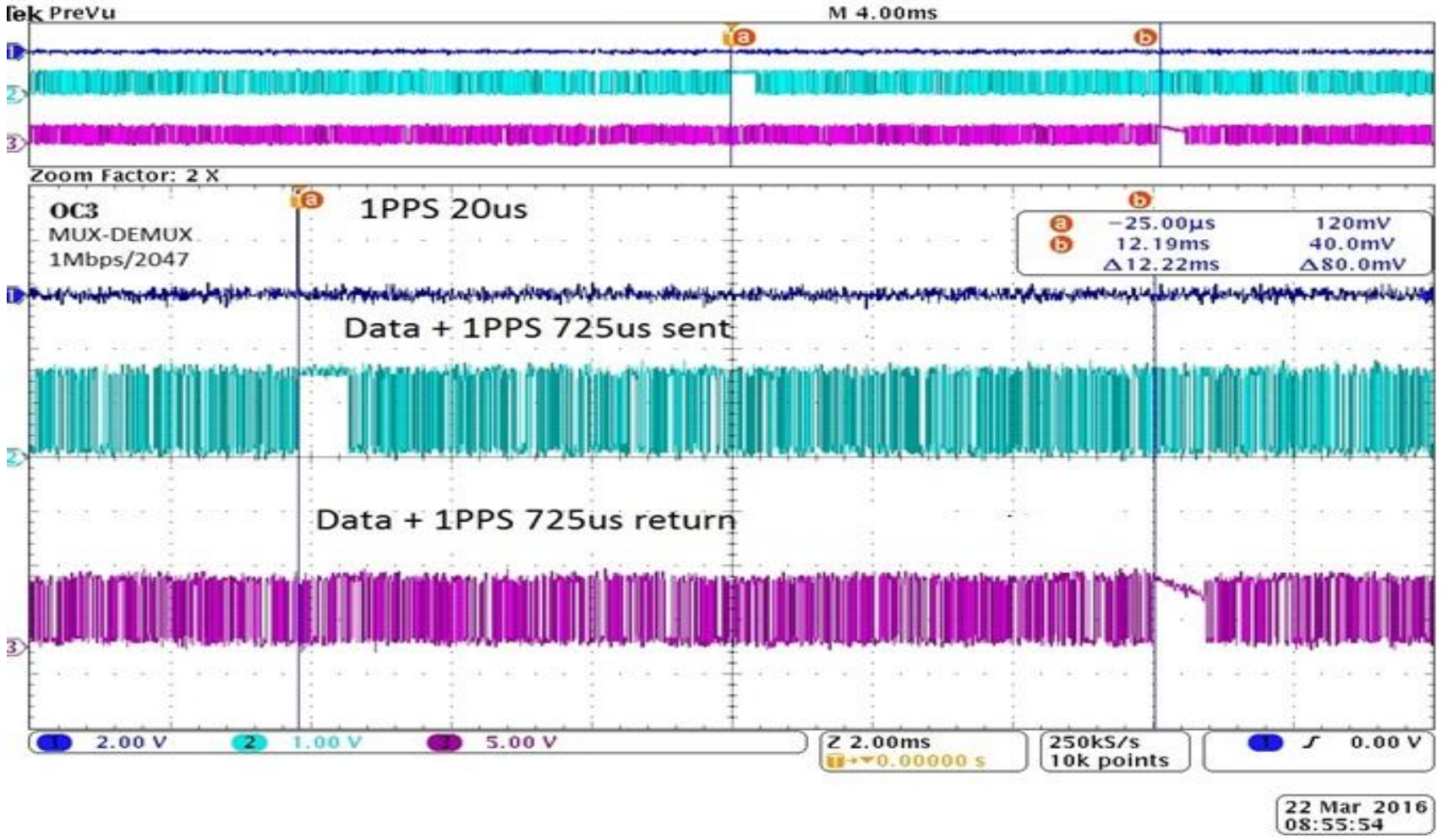
Measured latency of 1Mbps data going through OC-3 mux/demux on transmission line of ~3411.9312 m. one way (see next slides for o-scope picture and test set up)

- Average latency ~12.22 milliseconds (ms) (round trip)

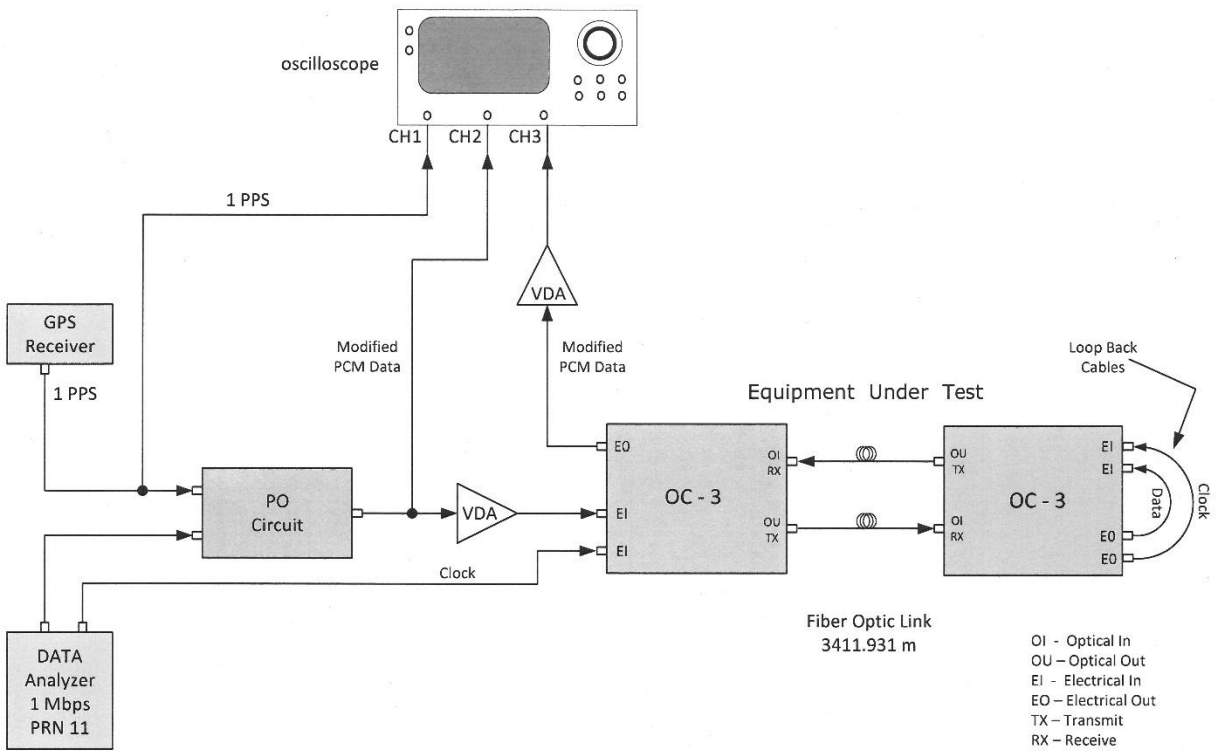
Measured latency of 1 Mbps data going though range Bit Sync # 1 and Bit Sync # 2

- BS # 1 average latency ~ 5 µs
- BS # 2 average latency ~ 4 µs

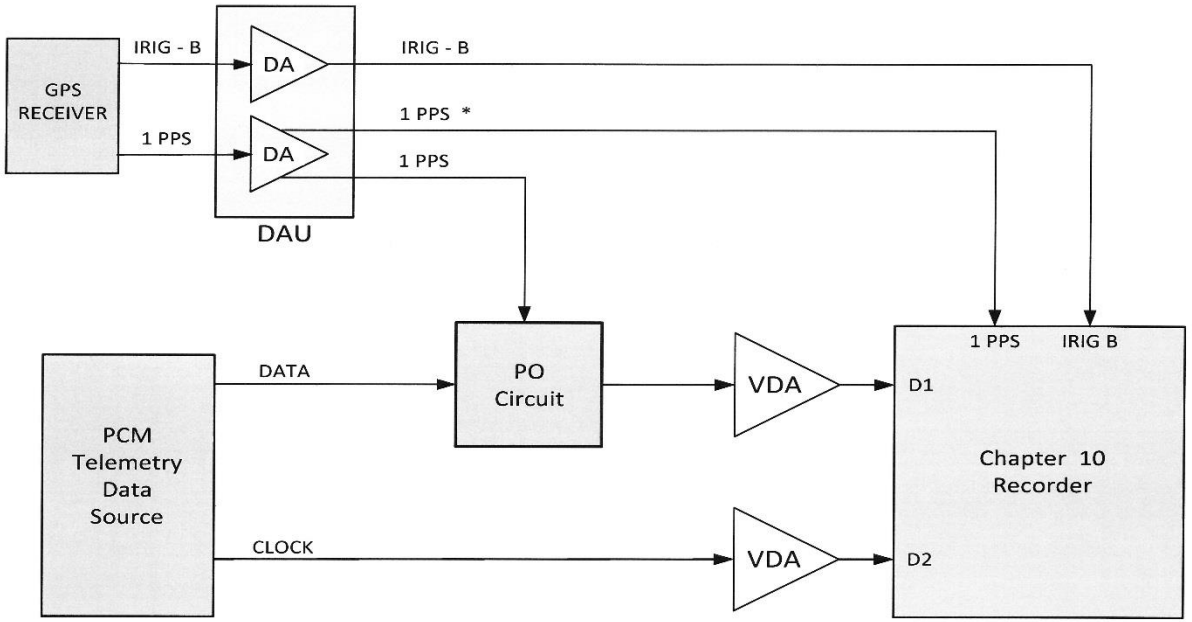
Preliminary Test Results



Propagation Delay Measurements Block Diagram



Chapter 10 Recorder Test Setup



* Test Setup: Without 1 PPS
With 1 PPS

DAU: Distribution Amplifier Unit

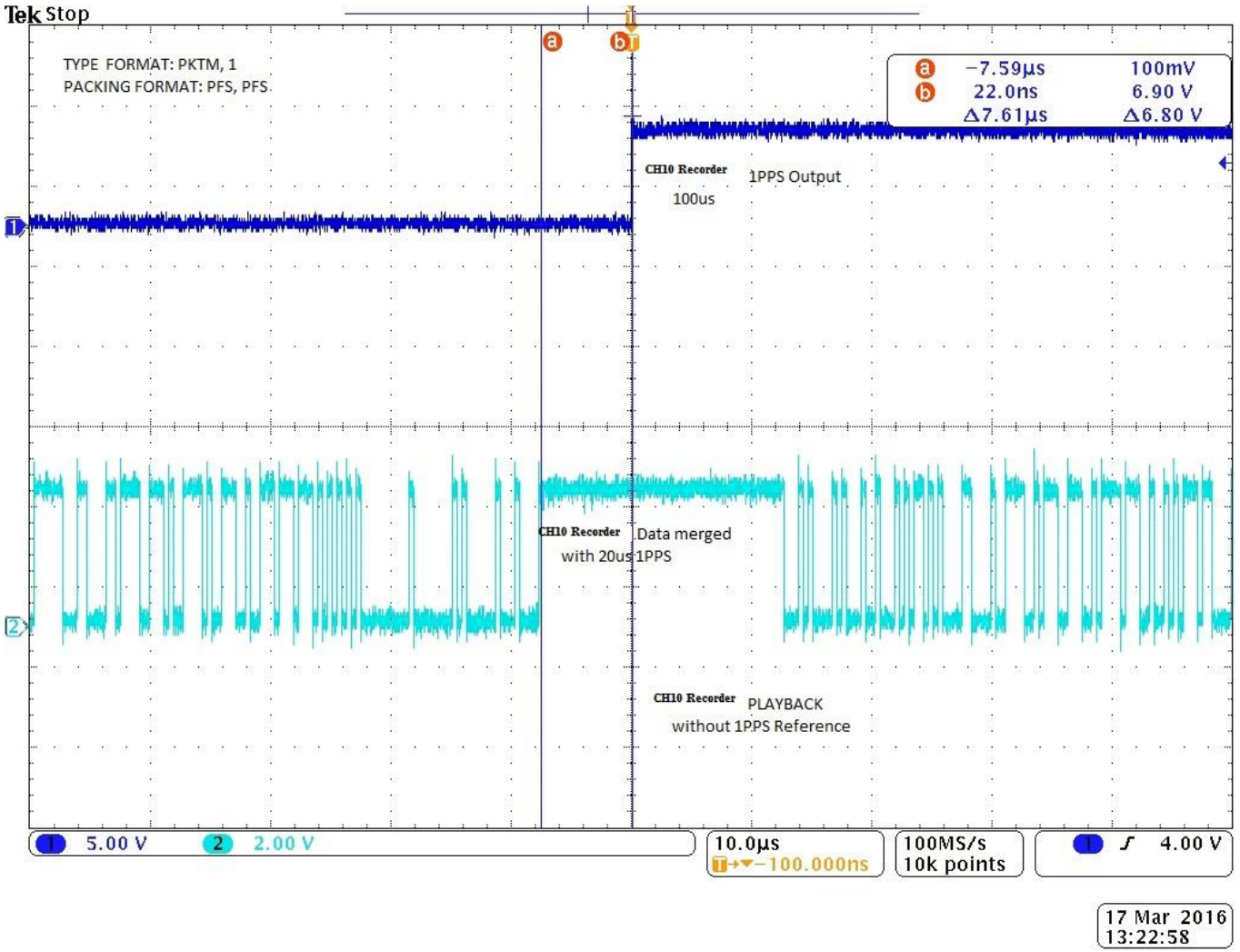
CH10 Recorder Test Results

Measured offset time stamp with merged 1PPS/PRN11 2.5 Mbps data being recorded onto CH10 Recorder **WITHOUT** 1 PPS connected recorder in packed mode

CH10 Time stamp offset ~6 to 8 µs .

Bytes Offset Hex	Bits Offset	1st PCM Bit Time	1PPS Delta time (s)	1st 1PPS Bit Time	Time Off (us)
1360	11	077:20:51:29.984184	0.0158076	077:20:51:29.9999916	8.40
0A44	10	077:20:51:59.991612	0.0083816	077:20:51:59.9999936	6.40
0134	0	077:20:52:29.999038	0.0009536	077:20:52:29.9999916	8.40
12DF	0	077:20:52:58.984602	0.0153904	077:20:52:58.9999924	7.60
11E8	3	077:20:53:25.985392	0.0146012	077:20:53:25.9999932	6.80
0C6F	3	077:20:53:57.989874	0.0101180	077:20:53:57.999992	8.00
0353	0	077:20:54:27.997302	0.0026912	077:20:54:27.9999932	6.80
1249	7	077:20:54:57.985078	0.0149132	077:20:54:57.9999912	8.80
020A	0	077:20:55:03.998354	0.0016384	077:20:55:03.9999924	7.60
092D	3	077:20:55:27.992505	0.0074860	077:20:55:27.999991	9.00
001C	5	077:20:55:57.999932	0.0000596	077:20:55:57.9999916	8.40
0C60	5	077:20:56:28.989921	0.0100708	077:20:56:28.9999918	8.20
				Average Time Offset	7.87

CH10 Recorder Without 1PPS Test Results PKS Mode



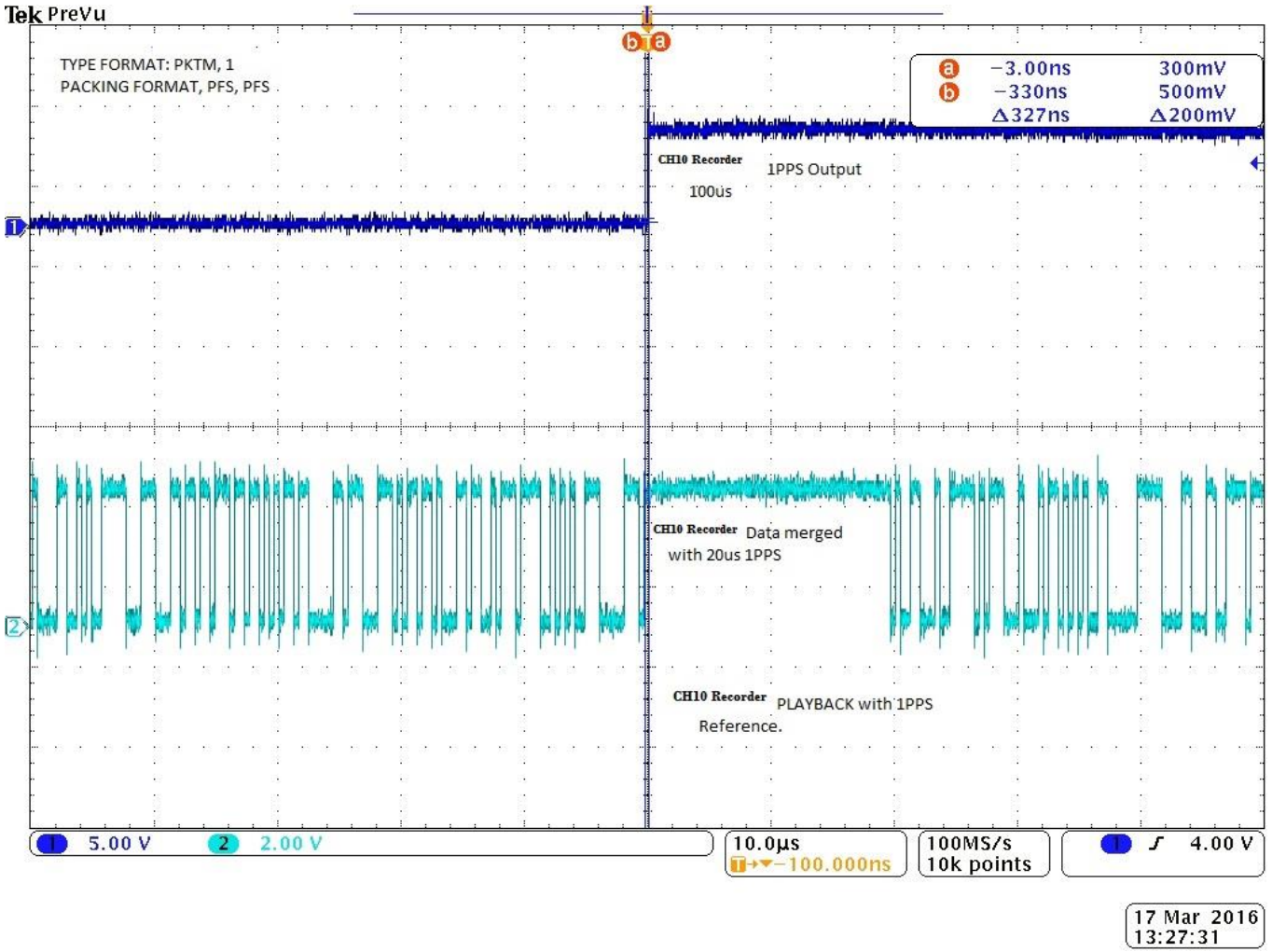
CH10 Recorder Test Results

Measured offset time stamp with merged 1PPS/PRN11 2.5 Mbps data being recorded onto CH10 Recorder **WITH** 1 PPS connected recorder in packed mode

CH10 Time stamp offset ~-0.6 to 1.0 µs.

Bytes Offset Hex	Bits Offset	1st PCM Bit Time	1PPS Delta time (s)	1st 1PPS Bit Time	Time Off (us)
08F3	6	077:20:42:57.992699	0.0073016	077:20:42:58.0000006	-0.60
0549	3	077:20:43:25.995701	0.0042988	077:20:43:25.9999998	0.20
1441	0	077:20:43:55.983476	0.0165232	077:20:43:55.9999992	0.80
00FB	0	077:20:44:11.999228	0.0007712	077:20:44:11.9999992	0.80
0B24	5	077:20:44:25.990904	0.0090964	077:20:44:26.0000004	-0.40
0D1D	4	077:20:44:55.989324	0.0106752	077:20:44:55.9999992	0.80
0400	7	077:20:45:25.996752	0.0032476	077:20:45:26. 9999996	0.40
12F8	4	077:20:45:55.984528	0.015472	077:20:45:56.0000000	-0.00
14E6	1	077:20:46:25.982949	0.0170512	077:20:46:26.0000002	-0.20
0BC9	4	077:20:46:55.990375	0.009624	077:20:46:55.999999	1.00
02B8	5	077:20:47:25.997803	0.0021972	077:20:47:26.0000002	-0.20
0759	4	077:20:47:54.994011	0.0059888	077:20:47:54.9999998	0.20
				Average Time Offset	0.23

CH10 recorder With 1PPS Test Results PKS Mode



Telemetry Processed Data Test Results

Measured offset time stamp of 2.5 Mbps data being archived on Data Server

- Data Server archives ~180 µs -300 µs offset time stamp for 2.5 Mbps data.

Offset Time Stamp	Slots #	Bit off	Updated second	Time offset
21:56:01.0002498	1850	8	1.0002498	-0.000250
21:56:02.0002206	481	2	2.0002206	-0.0002206
21:56:03.0002282	1159	1	3.0002282	-0.000228
21:56:04.0002492	1836	13	4.0002492	-0.0002492
21:56:05.0002218	467	10	5.0002218	-0.0002218
21:56:06.0002196	1145	6	6.0002196	-0.0002196
21:56:07.0002504	1823	2	7.0002504	-0.0002504
21:56:08.0002150	453	13	8.000215	-0.000215
21:56:09.0002222	1131	3	9.0002222	-0.0002222
21:56:11.0002202	440	2	11.0002202	-0.0002202

Display Station Test Results

The above image is a screen shot of the test 1PPS data pattern recorded with camera using IRIG-B time stamp. Camera time stamp is seen in left top corner of screen shot. Results show the viewable processed test 1PPS data pattern on the final Display Station System (DSS) delayed by ~28 ms. This offset varied between 20 ms to 80 ms.

Recommendations

This simple circuit validated vendor claims on time stamp accuracy and is an effective tool for accurately measuring signal propagation delay on telemetry and communication systems. This technique could be useful to other NASA centers or organizations using telemetry/communication systems.

Questions?